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⑪ Publication number: 0 438 225 A1

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## EUROPEAN PATENT APPLICATION

⑬ Application number: 91300131.9

⑮ Int. Cl. 5: G11B 7/24

⑭ Date of filing: 09.01.91

⑯ Priority: 19.01.90 JP 8458/90

⑰ Date of publication of application:  
24.07.91 Bulletin 91/30

⑲ Designated Contracting States:  
DE FR GB IT NL

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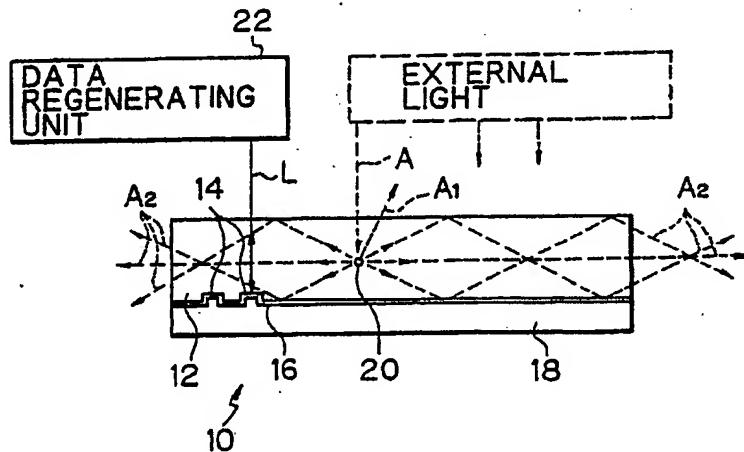
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㉓ A fluorescent optical disk.

㉔ An optical disk (10) comprising a plastic disk body (12) having fluorescent coloring material (20) dispersed therein. Pits (14) are provided on one of the surfaces of the plastic disk body (12), and a reflecting layer (16) is formed over the surface having the pits (14) and a protecting layer (18) is formed over the reflecting layer (16). When the optical disk (10) is subjected to an external light, the fluorescent coloring material (20) emits a radiation of a fluorescent light of a particular color, which can be seen at the opposite surfaces and the outer cylindrical surface of the optical disk (10). The optical disk (10) can be also subjected to a laser beam for regenerating data stored in the optical disk (10).

Fig. 1

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## A FLUORESCENT OPTICAL DISK

The present invention relates to an optical disk made of a plastic and having pits on one surface thereof for storing data therein, which can be regenerated by a light such as a laser beam.

Recent remarkable developments of optical disks have caused these optical disks to supplant conventional recordable disks in the field of sound recording, and further in the field of electronic computers when used as CD-ROMs.

5 The conventional recordable disk is provided with a continuous spiral groove for storing data as sound or in the form of analogue signals, but an optical disk is provided with discontinuous pits (recesses) on one surface of the plastic body of the disk, to store data as sound or in the form of digital signals. To this end, the pits are formed in a predetermined pattern on one surface of the plastic optical disk, and a reflecting layer is formed by an aluminum evaporation process over the surface of the disk having the pits.

10 In addition, a protecting layer is found over this reflecting layer. In the use of the optical disk, a laser beam is applied to the exposed surface of the plastic disk opposite to the surface thereof containing the pits, so that the laser beam is transmitted through the plastic disk from the exposed surface to the surface having pits, and is reflected at the reflecting layer. The reflected beam is again transmitted through the plastic disk and is emitted from the exposed surface, and the output light is delivered to the regenerating device for reading the data stored in the optical disk, based on the intensity of the output light.

15 There are many severe requirements for a material for constituting an optical disk. For example, such a material must have such properties as a high transparency, to allow a light to be transmitted therethrough with a low loss, a low birefringence, a low hygroscopicity, to prevent a warping of the optical disk, a high resistance to heat, a high fluidity during a molding process, a good demolding property upon completion of a molding process, and a low contamination by foreign substances and impurities. To satisfy these requirements, an acrylic resin such as polymethyl methacrylate resin was developed as a material for the optical disk, and recently, a polycarbonate resin has been developed for an optical disk intended for use in a hot environment; for example, in an audio system in an automobile.

20 25 A problem arises if the plastic optical disk contains a large amount of foreign substances and impurities in that, when the laser beam is transmitted through the plastic disk, the reflected light again transmitted through the plastic disk, the laser beam is absorbed by the foreign substances and impurities and the intensity of the output light becomes weak, and thus the signal to noise (S/N) ratio is lowered. Therefore, the development of optical disks has been concentrated on how to obtain a plastic material having a high transparency. It is, therefore, a conventionally immutable concept that a colorless transparent plastic material is used for the optical disk, and efforts have been made to establish a manufacturing process which precludes an entry of foreign substances and impurities to the optical disk.

30 35 As the popularity of optical disks becomes greater, a demand has arisen for a colored optical disk, for example, a red or yellow disk, but a plastic material inherently having a good transparency and a desired color is not known, and to obtain an optical disk having a desired color, it is necessary to mix a coloring material into a transparent plastic material. Nevertheless, a coloring material or a pigment for coloring is deemed to be an impurity, in view of the transmission of the laser beam, which absorbs the light to some extent, and accordingly, under the conventional concept of completely precluding foreign substances and impurities, it is not conceivable to use a coloring material at a region through which the laser beam is transmitted, and thus it is commonly considered that it is impossible to obtain a colored optical disk.

40 An object of the present invention is to provide an optical disk having a particular color and providing less absorption of a laser beam, to thereby enable a more sensitive regeneration.

45 According to the present invention, there is provided an optical disk comprising a plastic disk body having opposing first and second surfaces, with pits provided on the first surface, a reflecting layer formed on the pitted first surface of the plastic disk body, and a protecting layer covering the reflecting layer, the second surface being adapted to be subjected to a light, characterized in that the plastic disk body has a fluorescent coloring material dispersed in the plastic disk body.

50 With this arrangement, an external light will be incident on the optical disk regardless of whether or not it is used, and a component of the external light having a wavelength shorter than the wavelength of the fluorescent coloring material at which a fluorescent radiation is emitted is once absorbed in the fluorescent coloring material. The absorbed light energy is then converted into a fluorescent radiation which presents a particular color. In this way, the fluorescent radiation is induced by the external light having a wavelength in the visible range, so that, in usual circumstances where the optical disk can be seen, the fluorescent radiation is normally emitted and the optical disk appears to be colored. Also, in the use of the optical disk, a laser beam is applied to the optical disk for regenerating the stored data therein. The typical laser beam

has a wavelength of 780 nm, which is close to a boundary of a visible range of wave lengths on the infrared side. In contrast, the fluorescent radiation of a particular color has a wavelength within the visible range, and is shorter than 780 nm at the boundary of a wave length of the visible range on the infrared side. Therefore, the fluorescent coloring material absorbs a component of a light having a wave length shorter than the wavelength of a particular color within the visible range, but does not absorb the laser beam having a wavelength longer than the wavelength of a particular color. Accordingly, the laser beam is not substantially absorbed in the fluorescent coloring material when the laser beam is incident on the fluorescent coloring material and can be transmitted through the plastic disk without a reduction of the intensity of the light, to thereby enable a more sensitive regeneration of the data.

5 For a better understanding of the Invention and to show how the same may be carried into effect, reference will now be made to the accompanying drawings, in which:

Fig. 1 is a simplified longitudinal cross-sectional view of an optical disk according to the embodiment of the present invention;

10 Fig. 2 is a graph of the bit error rate versus the concentration of the fluorescent coloring material in the plastic optical disk;

15 Fig. 3 is a graph of measured examples of retardation of the plastic optical disk; and

Fig. 4 is a graph of a relative viscosity of the plastic optical disk versus the concentration of the fluorescent coloring material in the plastic optical disk.

Figure 1 is a longitudinal cross-section view of an optical disk 10 according to the present invention.

20 The optical disk 10 has opposing surfaces having a circular profile, as known in the art, although this profile is not shown. The optical disk 10 comprises a disk body 12 made of a plastic, and pits 14 are provided on one of the surfaces of the disk body 12. A reflecting layer 16 is formed on the surface of the disk body 12 having the pits 14, by an aluminum evaporation process, and a protecting layer 18 of epoxy resin is formed over the reflecting layer 16.

25 The plastic disk body 12 is made of a high transparency, CD grade polycarbonate resin, and a fluorescent coloring material 20 consisting of perylene is dispersed in the plastic disk body 12 of polycarbonate resin. The fluorescent coloring material 20 comprises numerous minute perylene particles, one of which particles 20 is schematically shown on an enlarged scale in Fig. 1. In the manufacture of the plastic disk body 12, the fluorescent coloring material 20 of perylene is first mixed and kneaded with the

30 polycarbonate resin in a screw extruding machine, to obtain colored pellets of a suitable size, while maintaining a predetermined concentration of the perylene in the polycarbonate resin. Then, the colored pellets are molded in an injection molding machine, in a clean room, to provide a plastic disk body 12 having the fluorescent coloring material 20 dispersed therein.

The fluorescent coloring material 20 to be dispersed in the plastic disk body 12 can be selected in accordance with a particular color desired. Preferably, the fluorescent coloring material 20 is selected from an organic material, because the organic material is easily dissolved in the polycarbonate resin, and thus is thoroughly dispersed in the polycarbonate resin. Especially, the perylene fluorescent coloring material 20 is dispersed homogeneously in the polycarbonate resin, in the form of minute particles, and is completely mixed with the polycarbonate resin on a molecular structural level to become a highly compatible mixture.

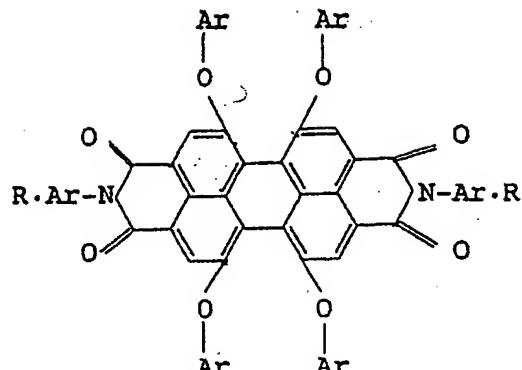
35 Accordingly, the perylene fluorescent coloring material 20 provides a lower possibility of a prevention of a transmission of the laser beam, as an impurity. In this regard, it is preferable to select the fluorescent coloring material 20 from the group consisting of a perylene derivative, imidazole derivative, BBOT, coumarin, and rhodamine. Examples of the perylene fluorescent coloring matter 20 having particular colors are as follows (in the following formula, Ar is an aryl group, and R is an atomic group such as an alkyl group).

[RED]

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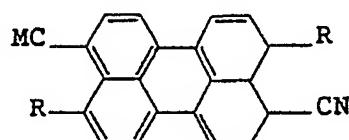
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[YELLOW]

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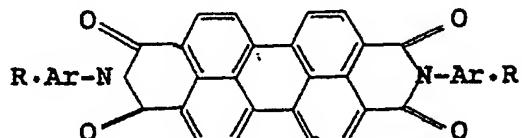
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[ORANGE]

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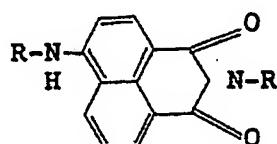
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An example of the imidazole derivative having a purple color is as follows.

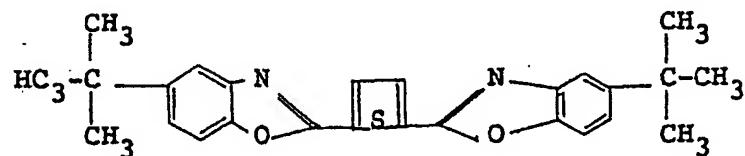
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An example of the BBOT (2,5-Bis[5-tert-butyl-2-benzoxazolyl]thiophene) having a blue color is as follows.

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In Fig. 1, the fluorescent coloring material 20 is shown in the form of one big particle, to clarify the description of the performance of the light, but in practice comprises numerous minute particles, and these numerous minute particles of the fluorescent coloring material 20 are mixed and dispersed in the plastic

disk body 12. An external light A will exist in a usual environment where the optical disk 10 can be seen by the human eye, and if the external light A is incident on the optical disk 10 and collides with the fluorescent coloring material 20, a component of the external light A having a wavelength shorter than the wavelength at which a fluorescent radiation is emitted is once absorbed in the fluorescent coloring material 20, and the absorbed light energy is then converted into a fluorescent radiation presenting a particular color. Accordingly, the optical disk 10 normally emits the fluorescent radiation and appears to be colored.

The external light A will be incident on the optical disk 10 in various directions, and collides with the fluorescent coloring material 20 at random angles. Therefore, the fluorescent radiations are generated in all directions and radially from the respective collision points, and thus advance in all directions. A portion of the fluorescent radiation orienting toward the upper surface of the plastic disk body 12 at an angle smaller than the critical angle will be emitted from the upper surface of the plastic disk body 12, as shown by the arrow A<sub>1</sub> in Fig. 1, and will present a particular fluorescent color at the upper surface of the plastic disk body 12. Another portion of the fluorescent radiation orienting toward the upper surface of the plastic disk body 12 at an angle larger than the critical angle will be totally reflected, and a further portion of the fluorescent radiation orienting toward the lower reflecting layer 16 will be reflected thereat. In this manner, a greater part of the fluorescent radiation will repeat the total reflection at the upper surface and the reflection at the lower surface, and is emitted from the cylindrical circumferential surface of the plastic disk body 12, as shown by the arrow A<sub>2</sub> in Fig. 1, and presents a strong fluorescent light ring at the cylindrical circumferential surface of the plastic disk body 12. This gives a very strong visual impression to the human eye. Also, it may be possible to functionally utilize this fluorescent light emitted from the cylindrical circumferential surface of the plastic disk body 12, for, for example, providing a reference point for an axial positioning of the optical disk 10 in an equipment, such as a CD disk deck. It may be also expected that the functions of the optical disk 10 are expanded by using this fluorescent light ring.

The optical disk 10 can be used in an audio equipment such as a CD disk deck, which usually includes a data regenerating unit 22 typically comprising a regenerating light source and a light receiving element (not shown) for the detection of data. A semiconductor laser having a wavelength of 780 nm is usually used as the light source. The semiconductor laser applies the laser beam L to the surface of the plastic disk body 12, and the light receiving element detects the intensity of the light reflected at the reflecting layer 16, the intensity of the light varying depending on whether or not pits 14 exists. To this end, the laser beam is transmitted through the plastic disk body 12 to the reflecting layer 16, and the reflected beam is again transmitted through the plastic disk body 12 and is directed toward the light receiving element after the beam is emitted from the plastic disk body 12. Since the fluorescent coloring material 20 is dispersed in the plastic disk body 12, and the relative position of the laser beam L to the plastic disk body 12 changes, the laser beam L may collide with the fluorescent coloring material 20 in some instances and may not collide therewith in other instances. When the laser beam L does not collide with the fluorescent coloring material 20, the laser beam L is not affected by the fluorescent coloring material 20 and it is possible to carry out the data regenerating process with an expected sensitivity.

When the laser beam L collides with the fluorescent coloring material 20, the laser beam L is affected by the fluorescent coloring material 20. The laser beam has a wavelength of 780 nm, which is close to a boundary of a visible range of wave lengths on the infrared side. In contrast, the fluorescent radiation has a wavelength of a particular color within the visible range, which is shorter than 780 nm at the boundary of a visible range of wave lengths on the infrared side. Therefore, the fluorescent coloring material 20 absorbs light having a wave length shorter than the wavelength of a particular color within the visible range, but does not absorb the laser beam having a wave length longer than the wavelength of a particular color. Accordingly, the laser beam L is subjected to less of an absorption which is an inherent action of the fluorescent coloring material 20 if the laser beam L collides with the fluorescent coloring material 20 and can be transmitted through the plastic disk body 12 without a reduction in the intensity of the laser beam L, to thereby enable a sensitive regeneration of the data. Namely, any reduction in the intensity of the laser beam L due to a dispersion of the fluorescent coloring material 20 in the plastic disk body 12 is small. In this regard, a wavelength of the fluorescent coloring material 20 presenting a particular color is preferably shorter than the wavelength of the laser beam L to be used.

While the laser beam L is not subjected to an absorption which is an inherent action of the fluorescent coloring material 20, an absorption occurs to some extent in that the laser beam L must collide with an impurity (the fluorescent coloring material 20), and thus the sensitivity of the regeneration is slightly reduced as the concentration of the fluorescent coloring material 20 in the plastic disk body 12 becomes larger. Figure 2 is an example of the bit error rate (BE/sec) of the optical disk 10, measured when the regeneration is carried out by using the red perylene fluorescent coloring material 20 and varying the concentration of the fluorescent coloring material 20 in the plastic disk body 12. The results show that it is possible to satisfy

the allowed level of 100 (BE/sec) in the recent CD disk standard, if the concentration of the fluorescent coloring material 20 in the plastic disk body 12 is lower than 1 percent.

Figure 3 shows measured examples of the retardation of a birefringence of the plastic optical disk 10, wherein the horizontal axis is a radial distance from the center of the optical disk 10. The solid line shows an optical disk of the prior art (not containing fluorescent coloring material), and the several broken lines show optical disks of the present invention containing fluorescent coloring materials of particular colors, i.e., red, lime, and orange. It will be seen that the retardation value is higher at the central region of the optical disk 10 and drops toward the peripheral region of the optical disk. This is a general tendency appearing equally in the optical disks of the prior art and of the present invention. Besides this tendency, there is no great difference between the optical disks of the prior art and of the present invention, and it can be understood that there is no substantial birefringence influence even if the fluorescent coloring material 20 is contained in the plastic disk body 12.

In addition, an advantage can be found in the manufacture of the optical disk 10 when containing the fluorescent coloring material 20 in the plastic disk body 12. Namely, when the plastic disk body 12 containing the fluorescent coloring material 20 is formed in a molding process, a demolding property, or a releasability of the product from the molding die, is improved and thus the manufacturing time is reduced.

Further, the inventors noted that the improvement of a demolding property prolonged the life of the molding die. The inventors analyzed this phenomenon and found that the mixing of the fluorescent coloring material 20 in the plastic disk body 12 improves a fluidity of the melt plastic material. Figure 4 is a view of a relative viscosity of the plastic disk body 12 (which is closely related to the fluidity of the melt plastic material) versus the concentration of the red perylene fluorescent coloring material 20 in the plastic disk body 12, at a temperature of 240 degrees Celsius. It is found that the relative viscosity drops as the concentration of the fluorescent coloring material 20 is increased. The relative viscosity when the concentration of the fluorescent coloring material 20 is 0.005 percent is about one half of that when the fluorescent coloring material 20 is not contained in the plastic disk body 12, and the demolding property is correspondingly improved.

As previously described, acrylic resin has been widely used for a material of the optical disk 10, since acrylic resin fully satisfies many requirements, but polycarbonate resin is now used for an optical disk 10 to be used in a hot environment. This is due to thermal properties of acrylic resin and polycarbonate resin. Namely, a melting point of acrylic resin is lower than that of polycarbonate resin, and thus the acrylic resin is superior to polycarbonate resin from the viewpoint of molding and demolding properties. Nevertheless, a deformation point of the product of acrylic resin is also lower than that of the product of polycarbonate resin. For example, a deformation point of a typical acrylic resin is about 80 degrees Celsius, and a deformation point of a typical polycarbonate resin is about 150 degrees Celsius, and thus the acrylic resin product may be deformed when used in a hot automobile. The optical disk 10 made of polycarbonate resin is preferable from the viewpoint of this heat deformation property, but the molding of polycarbonate resin is difficult, and thus a CD grade polycarbonate resin having a deformation point of about 135 degrees Celsius is now used. Nevertheless, the molding of a CD grade polycarbonate resin is still difficult.

As noted above, the inventors found that the mixing of the fluorescent coloring material 20 in the plastic disk body 12 improves a fluidity of the melt plastic material, as exemplified in Fig. 4, which improves the molding process and overcomes this difficulty. The inventors further found that this improvement of the fluidity of the melt plastic material improves not only the molding process but also the quality of the optical disk 10.

Referring again to Fig. 3, there is no substantial birefringence influence even if the fluorescent coloring material 20 is contained in the plastic disk body 12, as described above; an intensive inspection has revealed that the retardation of the optical disk 10 according to the present invention is improved at least the peripheral region of the optical disk 10. Namely, at the peripheral region of the optical disk 10 (a distance of more than 46 mm), the retardations plotted by the respective broken lines are lower than the retardation of the prior art shown by the solid line. Even at the central region, some of the retardations plotted by the respective broken lines are lower than the retardation of the prior art.

It is believed that the reduction of the retardation is caused by the improvement of the fluidity of the melt plastic material. Considering a molding process in which the melt plastic material is injected into the molding die from an inlet orifice at the center of the molding die, the molten plastic material flows first into the peripheral region of the molding die, and finally, fills the central region of the molding die. The volume of the peripheral region of the molding die is large, and preferably the molten plastic material flows smoothly into the peripheral region of the molding die, as such a smooth flow will ensure that the molten plastic material will solidify as a distortionless structure having a lower birefringence. The final flow of the molten plastic material is low, since the remaining space in the molding die becomes small and a distortion

will be caused in a resultant structure so that the retardation at the central region of the optical disk 10 becomes large. In this case too, a good fluidity is preferable, to create a smaller retardation. Also, the smaller the birefringence of the optical disk 10, the lower the bit error rate, since the birefringence causes a scattering of light which causes an increase of the chance of an inaccurate reading of the reflected light by the light receiving element.

5 Regarding the other properties of the optical disk 10, similar levels are maintained for the present invention and the prior art.

As explained above, an optical disk according to the present invention comprises a plastic disk body having a fluorescent coloring material dispersed therein, and the optical disk appears to have a beautiful 10 color. The laser beam is not substantially absorbed in the fluorescent coloring material, and so thus it is possible to carry out a sensitive regeneration of the data.

#### Claims

- 15 1. An optical disk (10) comprising a plastic disk body (12) having opposing first and second surfaces, with pits (14) being provided on said first surface, a reflecting layer (16) formed on said first surface with said pits of said disk body, and a protecting layer (18) covering said reflecting layer, said second surface being able to receive a light, characterized in that a fluorescent coloring material (20) is dispersed in said plastic disk body (12).
- 20 2. An optical disk as claimed in claim 1, wherein said fluorescent coloring material (20) is an organic fluorescent material.
- 25 3. An optical disk as claimed in claim 1 or 2, wherein said fluorescent coloring material (20) is a perylene derivative, imidazole derivative, BBOT, coumarin, or rhodamine.
4. An optical disk as claimed in claim 1, 2 or 3, wherein the concentration of said fluorescent coloring material (20) in said plastic disk body (12) is in the range of 0.005 to 1 percent.
- 30 5. An optical disk as claimed in claim 4, wherein the concentration of said fluorescent coloring material (20) in said plastic disk body (12) is in the range of 0.01 to 1 percent.
6. An optical disk as claimed in any preceding claim, wherein said plastic disk body (12) is composed of a plastic material which is polycarbonate resin, acrylic resin, epoxy resin, or polyolefin resin.

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Fig. 1

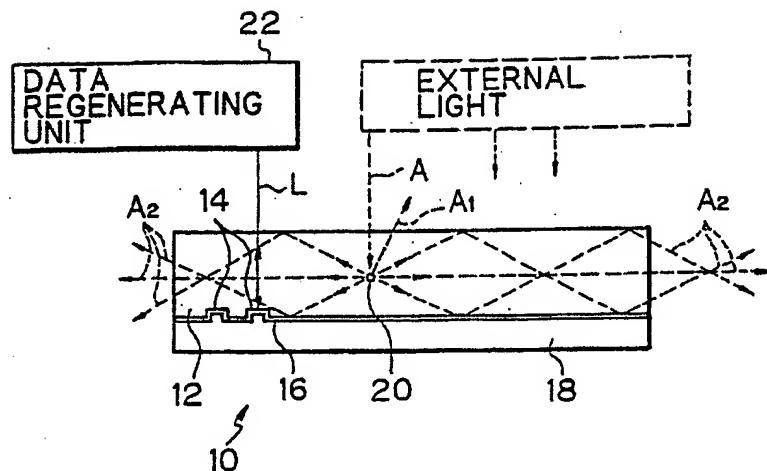


Fig. 2

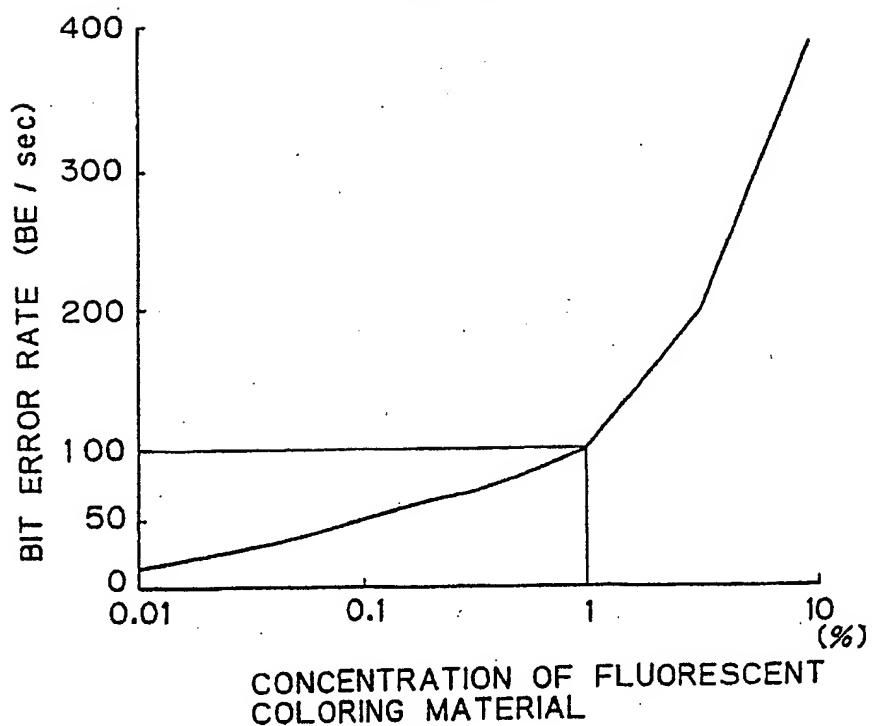


Fig. 3

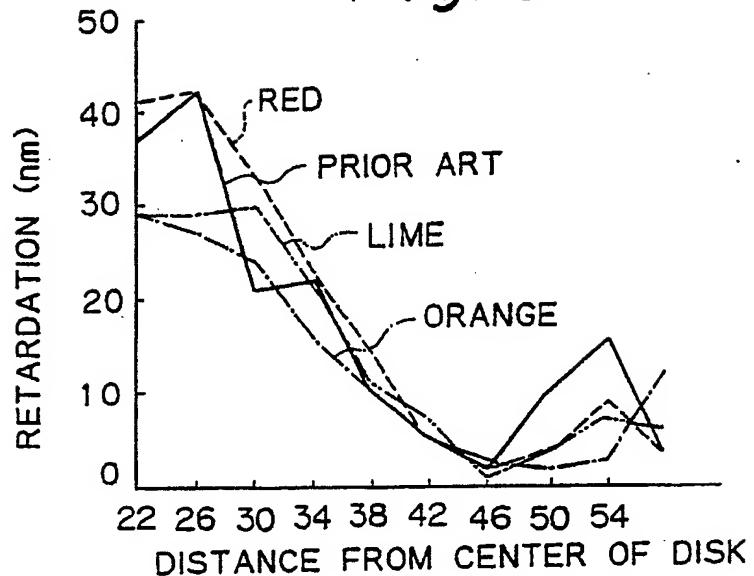
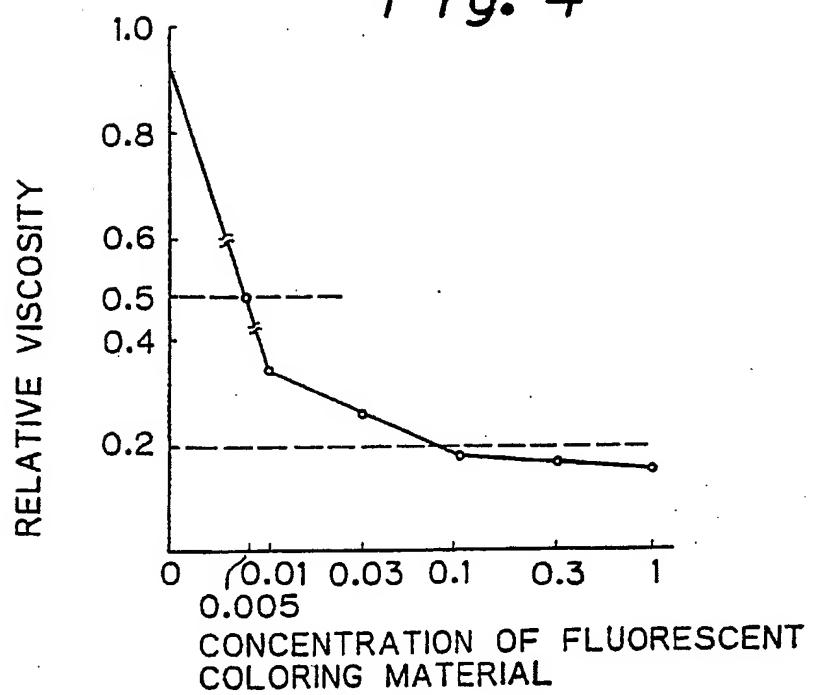


Fig. 4





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EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 91300131.9
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
Y	EP - A2 - 0 178 836 (POLYPLASTICS CO. LTD.) * Fig. 1; claim 1 *	1, 2	G 11 B 7/24
A	---	6	
Y	EP - A2 - 0 311 512 (FUJITSU LTD.) * Fig. 8; claims 8,9,10 *	1, 2	
A	---	3	
A	DATABASE WPIL, no. 86-321 567 DERWENT PUBLICATIONS LTD., London, GB * Abstract * & JP-A-61 236 891 (FUJI PHOTO FILM K.K.) 22-10-86 -----	1	
TECHNICAL FIELDS SEARCHED (Int. CL.5)			
G 11 B 7/00 G 02 B 1/00 C 09 K 11/00 B 29 D 11/00			
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
VIENNA	18-03-1991	BERGER	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			